REAC

DATA EVALUATION AND GROUNDWATER MODELING
VANCOUVER WELL FIELD
VANCOUVER, WASHINGTON
December, 1991

EPA Work Assignment No.: 3-568
Weston Work Order No. 3347-31-01-4568
EPA Contract No.: 68-03-3482

PRELIMINARY EVALUATION

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
ENVIRONMENTAL RESPONSE TEAM
EPA

OFFICE OF EMERGENCY AND REMEDIAL RESPONSE

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

1.0 INTRODUCTION

1.1 Site History

The Vancouver Well Field consisting of Water Station #4 (WS4) is located in the southern portion of the city of Vancouver, Washington (Figure 1). WS4 is located at approximately one-half mile north of the Columbia River and consists of six production wells which had supplied potable water to the city of Vancouver until 1987 when elevated tetrachloroethene (PCE) concentrations were detected in the groundwater.

The city of Vancouver has conducted various studies and investigations to attempt to identify the potential source(s) and extent of contamination both in soil and groundwater. Various reports have been prepared by Rittenhouse-Zeman & Associates, Inc. (RZA) (1990a, 1990b, 1991a, 1991b). PCE has been detected in the groundwater supply in at least 14 production and monitor wells ranging from non-detected to 795 parts per billion (ppb), with most wells containing PCE at 2 to 50 ppb (August, 1991 data). Other contaminants found in groundwater at concentrations ranging from 1 ppb to 10 ppb at various wells include trichlorofluoromethane, chloroform, 1,1,1-trichloroethane, benzene, toluene, ethylbenzene, and xylene. RZA (1990a) has suggested that some sources of the PCE may be from dry cleaners located upgradient of the water supply wells.

Recent groundwater analytical results (August, 1991 data) from groundwater sampled, at the Mercer Well located approximately 900 feet north-east and upgradient of WS4 (Figure 1), indicate a sharp increase of PCE from non-detectable (ND@0.20 ppb) in May, 1990 to 795 ppb in August, 1991.

The United States Environmental Protection Agency (U.S. EPA) On-Scene Coordinator (OSC) has recently proposed a remedial plan to pump the Mercer Well at 100 gallon per minutes (gpm) in an attempt to prevent the contaminant plume from migrating further towards the WS4.

1.2 Objectives and Scope

U.S. EPA Environmental Response Team (ERT) has requested the Response Engineering and Analytical Contract (REAC) to construct a preliminary groundwater model and use the model to evaluate the Mercer Well remedial pumping plan proposal, and to attempt to identify potential source areas.

In response to the request by ERT, REAC has collected information from various sources, evaluated the data received, constructed a preliminary groundwater model, and made a preliminary evaluation based on the available information and the model.

2.0 METHODS

2.1 Background Information

REAC and U.S. EPA Environmental Resource Center (ERC) had conducted a literature search for information related to the site geology, hydrogeology and other related subjects. Pertinent maps, professional articles and reports found during the literature search were ordered through the interlibrary loan system. Those materials received before this evaluation was completed are listed in Section 6.0, References.

2.1.1 Topography

The site area is situated on the Columbia River floodplain, and occupies part of a floodplain and also includes two terraces. The approximate elevation of the floodplain is 20 feet above mean see level (AMSL), and the two terraces are located at approximately 140 and 300 feet AMSL. Steep bluffs are located between the floodplain and terraces. The entire area has been heavily developed with residential houses and commercial buildings. The Columbia River is south of the site area, and Burnt Creek is to the north. The Columbia River and Burnt Creek are flowing west to north-west.

2.1.2 Hydrology

The annual precipitation in the Vancouver area was estimated as 39 inches (Bhagat, 1977). Monthly precipitation ranges from an average of six inches in the winter time to one-half inch in summer. The Columbia River level fluctuates as a result of storm floods, tidal effects, and seasonal fluctuations. The base river level of the seasonal fluctuation ranges from two feet AMSL in summer, to eight feet AMSL in winter. The fluctuation caused by the daily tidal effect is proximately two and one-half feet. A storm flood may cause the river level to rise up to seven feet over a short duration of time.

2.1.3 Hydrogeology

The geology of the Vancouver, Washington area is comprised of a wide variety of Cenozoic lithologic units. The geologic basement is composed of basaltic igneous rock, which is overlain by younger sedimentary bedrock units. Above the bedrock, younger unconsolidated sediments have been deposited. Presented in this section is a geologic and hydrogeologic discussion of the various lithologic units, from the oldest (deepest) to the youngest.

2.1.3.1 Columbia River Basalt

The Columbia River Basalt Group (Middle Miocene) in the Vancouver area is represented by the Wanapum and Grande Ronde Basalt Formations (Swanson, et al., 1979) (Figure 2). These units locally represent the geologic basement, and have been described by Baldwin (1981) to consist of up to 2,000 feet of flood basalt erupted from vents in eastern Washington. These basalts flowed from the ancestral Cascade range into lower lying areas. Individual flows generally consist of solid basalt with columnar or block cooling joints. Interflow zones of rubbly or scoriaceous basalt are frequently important regional aquifers (Dames & Moore, 1985).

The basalts of the Vancouver area are not utilized locally as an aquifer. Within Vancouver these units occur at a minimum depth of 850 feet, which make the shallower, younger units above (see discussion below) more attractive targets as potable ground water sources.

2.1.3.2 Troutdale Formation

The Troutdale Formation (Miocene to Pleistocene) overlies the Columbia River Basalts in the Vancouver area. This Formation includes both a lower and an upper member (Mundorff, 1963).

The Lower Member of the Troutdale Formation

The Lower Member of the Troutdale Formation consists mainly of siltstone, silty shale, and shale (Trimble, 1964) deposited in a lacustrine environment into a subsiding basin (Chaney, 1944). The thickness of this unit is approximately 650 feet in the Vancouver area, and occurs at a minimum depth of 190 to 200 feet (beneath the Columbia River floodplain) (Figure 2). Due to the relatively poor transmissivity of this unit, and the availability of shallower, more transmissive units above, the Lower Member of the Troutdale Formation is not utilized locally as a potable ground water source.

The Upper Member of the Troutdale Formation

The Upper Member of the Troutdale Formation consists of indurated sand, cemented sandstone, sandy gravel, and conglomerate with localized silty lenses and layers (Trimble, 1964). A fluvial environment accounted for the deposition of these sediments, from streams that drained the Cascade range as it was uplifted during the Pliocene. The unit consists of a lower layer of cobbly, sandy gravel which is poorly cemented, and an upper layer of cemented gravel (conglomerate), typically weathered to a depth of several feet (Mundorff, 1964).

The top of the Upper Member of the Troutdale Formation is encountered at an approximate depth of 105 feet below the Columbia River floodplain (at -75 feet MSL), outcrops at an elevation of approximately 150 feet MSL on the top of the first bluff just north of the river, and at approximately 115 feet beneath the top of the second bluff north of the river (at 175 feet MSL) (Figure 2). The unit ranges in thickness from approximately 90 feet below the Columbia River floodplain, to approximately 340 feet beneath the second bluff north of the river. The varying thickness of the unit is due to erosional processes associated with the Columbia River during Pleistocene time.

The lower, poorly cemented, coarse-grained layer of the Upper Troutdale locally serves as a major ground water aquifer. Because of the lenticular nature of beds deposited within the fluvial system, yields from adjacent wells may vary considerably. Ground water within this layer of the Upper Troutdale is commonly found to be confined, and wells screened within it are commonly found to be artesian (Dames & Moore, 1985). The upper layer of the Upper Troutdale serves as the confining layer, and therefore is not used locally as a ground water source.

2.1.3.3 Orchards Gravel

The Orchards Gravel Formation (Pleistocene), an unconsolidated, glacio-fluvial deposit, lies unconformably upon the bedrock of the Troutdale Formation (Figure 2). Pleistocene flooding down the Columbia River was responsible for scouring the upper Troutdale Formation within the Columbia River Valley, and also for building a large delta of coarse gravelly material into the Portland Basin (Trimble, 1963). These deposits range in thickness from approximately 75 feet beneath the Columbia River floodplain, to zero feet in thickness at the top of the first bluff north of the river, to approximately 120 feet at the top of the second bluff north of the river.

Beneath the Columbia River floodplain in the Vancouver area, the Orchards Gravel is comprised mostly of coarse-grained sand and gravel deposits. Above the floodplain, finer grained materials (fine to medium grained sands) are present as stringers and lenses within the gravels and coarser sands, again accountable to the lenticular nature of fluvial depositional processes.

The Orchards Gravel is an important local ground water source, and serves with the Upper Troutdale Formation as the areas major ground water aquifer. The Orchards Gravel has strong hydraulic communication with the Columbia River (Dames & Moore, 1985).

2.1.3.4 Holocene Alluvium

Subsequent to the glacio-fluvial deposition of the deltaic system within the Portland basin during the Pleistocene, the Columbia River began incising the unconsolidated deposits. This process began in the Holocene, and has continued to present. The current Columbia River Channel began being developed less than 6,000 years before present. Fine-grained sand and silt alluvium deposits are found within the Columbia River floodplain, and range in thickness from zero feet at the margin of the floodplain, to approximately 30 feet within the flood plain (Figure 2).

2.1.4 Production Wells

There are several wells which withdraw groundwater from the aquifers in the site area. The Water Station #1 (WS1)(Figure 1), located 8,700 feet north-west of the WS4, pumps at an average rate of 4,000 gpm with a maximum rate of 16,000 gpm. WS4 has a maximum pumping capability of 8,000 gpm, and has been pumping at an average rate of 4,000 gpm. The FMC, Inc. facility located near the Columbia River has production wells capable of pumping 4,000 gpm. The Washington School for the Deaf has an irrigation well, and its pumping rate is unknown.

2.1.5 Groundwater Flow Direction

Table 1 is a compilation of the groundwater potentiometric data from various RZA reports. The data are posted on Figure 1. The posted data are probably not from a single measurement event. Since the groundwater fluctuates frequently with river levels and different pumping schedules, this data set is not appropriate to be used to determine the groundwater elevation contours. They could only supply us with a general idea of the groundwater fluctuation ranges.

Several reports (U.S. EPA, 1978; RZA, 1990b) describe the groundwater contours in the site area as following subdued topographic contour. Generally, groundwater flows towards the south to south-west towards the Columbia River.

2.1.6 Contaminants in Groundwater

The primary groundwater contaminant in the site area is PCE. The highest PCE level detected in groundwater was 795 ppb (Mercer Well, June, 1991). Analytical results for other wells revealed PCE concentrations under 70 ppb. The U.S. EPA proposed Maximum Contaminant Levels (MCL) for drinking water for PCE is 5 ppb (U.S. EPA, 1991). Table 2 contains PCE analytical data for the various monitor and production wells. Figure 3 contains the posted maximum PCE concentration found in groundwater at each location in Table 2.

RZA (1990) has suggested that the source of PCE may be from various dry cleaners located upgradient of the WS4 water supply wells. These potential source areas are indicated on the report base map as DRY1, DRY2, and DRY3.

2.2 Groundwater Modeling

Accurate groundwater modeling normally requires accurate aquifer pumping test data to provide the aquifer transmissivities and groundwater level measurements to calibrate the model. Neither of these requirements were available prior to the development of this preliminary model. Therefore, the results of this preliminary modeling effort should serve as a guiding tool to collect additional information and data, which will allow for confirmation of the assumptions. This in turn, will lead to a more refined and accurate model in the future. Meanwhile, this model should serve as tool to evaluate the Mercer Well remedial pumping plan proposal.

2.2.1 Physical Conceptual Model

Based on the geological and hydrogeological setting described above, a physical conceptual model of the aquifer system was created as described as follows:

A single layer, unconfined aquifer system was used to simulate the well field aquifers consisting of the Orchards Gravel and Troutdale Formations. The bases of the aquifers are assumed to be 90 feet below AMSL. The aquifer within the Troutdale Formation has a lower transmissivity than the Orchards Gravel formation aquifer. A uniform infiltration rate covering the entire aquifer recharge area was utilized. Fixed levels were set for the Columbia River boundary and Burnt Creek and were defined to be interconnected with the aquifer system.

At this stage of modeling, only the steady state condition reflecting a long-term average condition was modeled.

2.2.2 Model Selection

The Single Layer model (SL) developed by Strack (1989) was selected for this preliminary modeling. SL is a two dimensional groundwater flow and contaminant transport model. This model employs the analytical element method which evolved from the boundary integral theory. The major advantage of this model is that the flow domain is continuous, compared to the traditionally employed finite element and finite difference methods which generate outputs only at the discrete nodes. A continuous flow domain makes possible the tracing of the contaminant sources and can be used to predict plume migration patterns in a complicated hydrogeologic setting such as a well field which has multiple pumping wells, as is the case with the Vancouver Well Field.

2.2.3 Assumptions

The average infiltration from precipitation, through the soil column to the groundwater, was assumed to be 0.004 feet per day (17.5 inches per year), 45 percent of the average annual precipitation (39 inches per year).

The groundwater gradient in the Orchards Gravel Formation aquifer was assumed to be 0.4 percent based on "the subdued topographic grade" (RZA, 1990b).

The porosity of the Orchards Gravel Formation aquifer was assumed to be 20 percent based on the typical porosities of sand and gravel (Fetter, 1990).

The permeability of the Orchard Gravel Formation was assumed to be 115 feet per day which was calculated based on the velocity of 2.25 feet per day (U.S. EPA, 1987) and the assumptions made of porosity and the hydraulic gradient.

The Columbia River level was assumed to be at five feet above mean sea level.

The Burnt Bridge Creek was assumed to be interconnected with the groundwater table. Constant piezometer heads were maintained at various locations consistent with topographic contours (Figure 1).

Water Station #1 (WS1) was assumed to be pumping at its average rate of 4,000 gpm. The actual number of wells in this wellfield is unknown. The model tested the scenarios of WS4 pumping at zero, 4,000, and 8,000 gpm.

Table 3 lists the main assumptions utilized in the model along with the estimated values found in the secured literature.

2.2.4 Model Layout

The model SL requires the assignment of hydraulic features (i.e., river, transmissivity values) for specific segments along the boundary of aquifer features, such as the Columbia River, and the boundary between the two different aquifer transmissivity zones (Orchards Gravel and Troutdale Formations aquifers). Unique analytical elements are assigned to these segments. The river and creek elements are laid directly over the basemap, as indicated in Figure 5. The boundary between the Troutdale and the Orchards Gravel Formation aquifers is determined by drawing a line tracing the bluff between terraces as indicated in Figure 5. The inhomogeneity elements are superimposed over this line. The transmissivity north of this line is lower than that in the south.

2.2.5 Model Calibration

Figure 6 shows the output of the model of the current condition where WS4 is not pumping, and WS1 pumping at its average rate of 4,000 gpm (i.e., current condition). This figure also contains groundwater elevation data. Despite the groundwater data being obtained on different dates, and although these data may not be used to calibrate the model, the data generally fits the range of the groundwater contours generated by the model.

3.0 RESULTS

In that potentiometric data collected on the same date was not made available for the preparation of this preliminary model, it is difficult to make firm conclusions. The findings and results of this preliminary evaluation are subject to future modifications when more reliable data becomes available. This evaluation serves to provide guidance to direct future data collection activities. However, some preliminary findings can be made from the previously mentioned assumptions and the general nature of unconfined aquifers.

3.1 Static Condition

Figure 7 depicts the modeled groundwater table contours of the natural background (static) condition in which both WS1 and WS4 are not pumping. In this case, groundwater generally flows from the Troutdale Formation under the terrace south to south-west towards the Columbia River.

3.2 Condition with WS4 pumping at 4000 gpm

Figure 8 depicts the condition where WS4 is pumping at its long-term average rate of 4,000 gpm and WS1 is pumping at its average rate of 4,000 gpm. This condition reflects a long-term average flow condition prior to the shut-down of WS4. As shown, groundwater draw by WS4 appears to be equal from all directions. This suggests that the contamination detected in WS4 groundwater could come from any directions, including the three dry cleaners suggested by RZA (1990).

3.3 Condition with WS4 pumping at 8000 gpm

Figure 9 depicts the condition where the WS4 is pumping at its peak rate of 8,000 gpm and WS1 pumping at its average rate of 4,000 gpm. This condition should reflect peak summer time water demand.

3.4 Condition with Mercer Well pumping at 100 gpm

Figure 10 depicts the Mercer Well pumping at 100 gpm and WS1 pumping at its average rate of 4,000 gpm. This simulates the recent proposal by the U.S. EPA OSC to attempt to capture contamination which may be migrating from the Mercer Well area to WS4.

4.0 DISCUSSIONS

4.1 Contaminant Plume and Migration

Based on the available number of wells and sample results, the contamination in groundwater appears to occur in a large area of over two miles in the east-west direction and one mile in the south-north direction. The current information can not sufficiently delineate the contaminant plume or plumes. Within the area enclosed by the available data, the distance between the sample points is roughly a thousand feet. The spacing is too large to show sufficient evidence of linkage between the adjacent data points, and therefore does not allow for accurate delineation of plume boundaries or identification of source areas.

The contaminant migration should follow approximately the groundwater flow line as indicated in the model results, with some degree of dispersion and diffusion.

Despite the transient groundwater flow patterns caused by various factors, the preliminary modeling results indicates there is no evidence to suggest that the PCE contamination is capable of migrating parallel to the Columbia River unless under average pumping conditions of WS4. Therefore, the PCE contamination detected at the Mercer well may be from DRY2, but not from DRY1 and DRY3. PCE contamination detected at WS4 during average pumping conditions (prior to wellfield shutdown) may be from the three identified dry cleaner sources. Additional wells are needed to evaluate accurately whether any of the dry cleaners were actually sources of PCE contamination.

4.2 Transient Groundwater Flow

Figures 8 and 9 indicate the differences between the groundwater flow pathlines under the different pumping rates at WS4. The past pumping conditions had a tendency to spread out the contaminants on both the east and west sides of the WS4, causing the contaminants to migrate following different pathways at different times.

The Columbia River fluctuations caused by storm flood and tidal effects should have impacts on the groundwater flow patterns. In some areas near the shore line of the river, the groundwater could be reversed to flow inland for a certain distance during flood or tidal surges. This may cause the contaminant plume or plumes to migrate towards or away from the Columbia River in certain areas. In the future with more accurate potentiometric and river elevation data, a transient groundwater model reflecting the true conditions can be constructed. This future model could then be used to evaluate various pump and treat remedial options.

4.3 Mercer Well Pumping Plan

The proposal of pumping 100 gpm from the Mercer Well will proximately capture a stretch of groundwater 200 feet wide as indicated in Figure 10. The source of the contamination found in Mercer Well is probably located directly upgradient of the Mercer well. The extent of the plume near the Mercer Well is not defined, and is probably larger than the capture range of this proposed plan. If this plan is imposed, the contamination probably will continue to flow down-gradient toward the WS4, passing the Mercer Well.

5.0 RECOMMENDATIONS

In order to define the groundwater flow pattern accurately, frequent and complete a groundwater level measurements are necessary. Groundwater levels should be measured initially on weekly a basis. Each measurement event should be completed within a short period (i.e., less than eight hours). After a few months, if the results are consistent, the measuring frequency could be reduced.

This site does not have a sufficient number of monitoring wells to delineate the contaminant plumes, or generate accurate groundwater potentiometric contours. More monitoring wells are needed.

Pumping tests of the Orchards and Troutdale aquifers are needed to develop more accurate values for transmissivity and storativity. A pumping test at the Orchard aquifer may be subject to the transient groundwater effect, therefore hydrographs of the groundwater potentiometric levels are needed before the design of the pumping tests. Additionally, hydrographs of the Columbia River and key monitor wells are also recommended in order to characterize the hydraulic relationship between flood or tidal surges and the migration of the contaminant plumes.

After obtaining the accurate data of groundwater level and pumping test results, a more refined groundwater model could be generated. A transient and contaminant transport model could also be applied in simulating the groundwater flow and the contaminant migration patterns. Also remedial alternatives could be evaluated with greater certainty.

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Tables

TABLE 1

GROUNDWATER POTENTIOMETRIC DATA, (ft AMSL)

VANCOUVER WELL FIELD
VANCOUVER, WASHINGTON
December, 1991

WELL	06/20/90	09/09/91
BUMP	0.00	NDA
CHR1	36.00	NDA
CHSU	NDA	NDA
DP1	50.05	54.87
DP2	80.76	80.92
EZETTA	165.00	NDA
FHCW	7.00	0.24
FS1	9.32	6.07
FS2	9.29	6.16
HILL	60.00	NDA
HS1	8.92	6.16
HS2	8.95	6.22
HUTTON	78.00	NDA
MERCER	15.00	15.00
MYERS	130.00	NDA
PARKHC	96.00	96.00
PHC	93.94	94.12
PHIL	NDA	NDA
PORTCO1	4.00	NDA
PORTCO2	5.00	NDA
PZ13	14.00	NDA
SCHO	6.00	6.00
WS4	10.00	NDA
WSSD	2.00	2.00

Data Source: RZA, Inc. (1991)
NDA: No data available

TABLE 2

TETRACHLOROETHENE (PCE) ANALYTICAL DATA

Results in ug/l (ppb)
VANCOUVER WELL FIELD
VANCOUVER, WASHINGTON
December, 1991

WELL	05/16/90	12/5-6/90	8/1-7/91
BROOK	NDA	0.77	NDA
BUMP	19.80	NDA	NDA
CC1	NDA	NDA	0.20
CC2	NDA	NDA	ND@0.13
CC3	NDA	NDA	0.20
CHR1	2.12	2.60	NDA
CHSU	3.26	NDA	NDA
DP1	0.37	0.89	2.28
DP2	53.28	66.70	48.10
EZETTA	NDA	NDA	NDA
FHCW	3.73	12.00	9.00
FS1	13.26	10.40	17.30
FS2	3.16	7.20	2.90
HILL	NDA	NDA	NDA
HS1	2.15	6.40	7.11
HS2	0.61	2.00	5.71
HUTTON	0.22	0.70	NDA
MERCER	ND @0.20	65.10	795.00
MYERS	NDA	NDA	NDA
PARKHC	1.09	0.80	ND@0.08
PHC	4.84	4.00	5.50
PHIL	ND @0.20	NDA	NDA
PORTCO1	NDA	NDA	NDA
PORTCO2	NDA	NDA	NDA
PZ13	1.18	3.10	NDA
SCHO	9.57	7.90	28.10
WS4	3.40	5.60	NDA
WSSB-B	NDA	NDA	3.06
WSSD	0.56	NDA	1.43

Data Source: RZA, Inc. (1990b, 1991a, and 1991b), EPA method 8010 (GC method)
NDA: No data available
ND: Not detected @Detection Limit

TABLE 3

MODEL ASSUMPTIONS

VANCOUVER WELL FIELD
VANCOUVER, WASHINGTON
December, 1991

ITEM	ESTIMATED RANGE	ASSUMPTION
Aquifer Base of Orchards Gravel		-75 feet AMSL
Aquifer Base of Troutdale Formation		-75 feet AMSL
Columbia River Level, ft AMSL	0 to 10 feet AMSL	feet AMSL
Infiltration		17.5 inch per year
Porosity of Orchards Gravel		20 %
Porosity of Troutdale Aquifer		20 %
Permeability of Orchards Gravel		115 feet/day
Transmissivity of Troutdale Formation	10,000 to 30,000 gpm/foot	20,000 gpm/foot

Figures

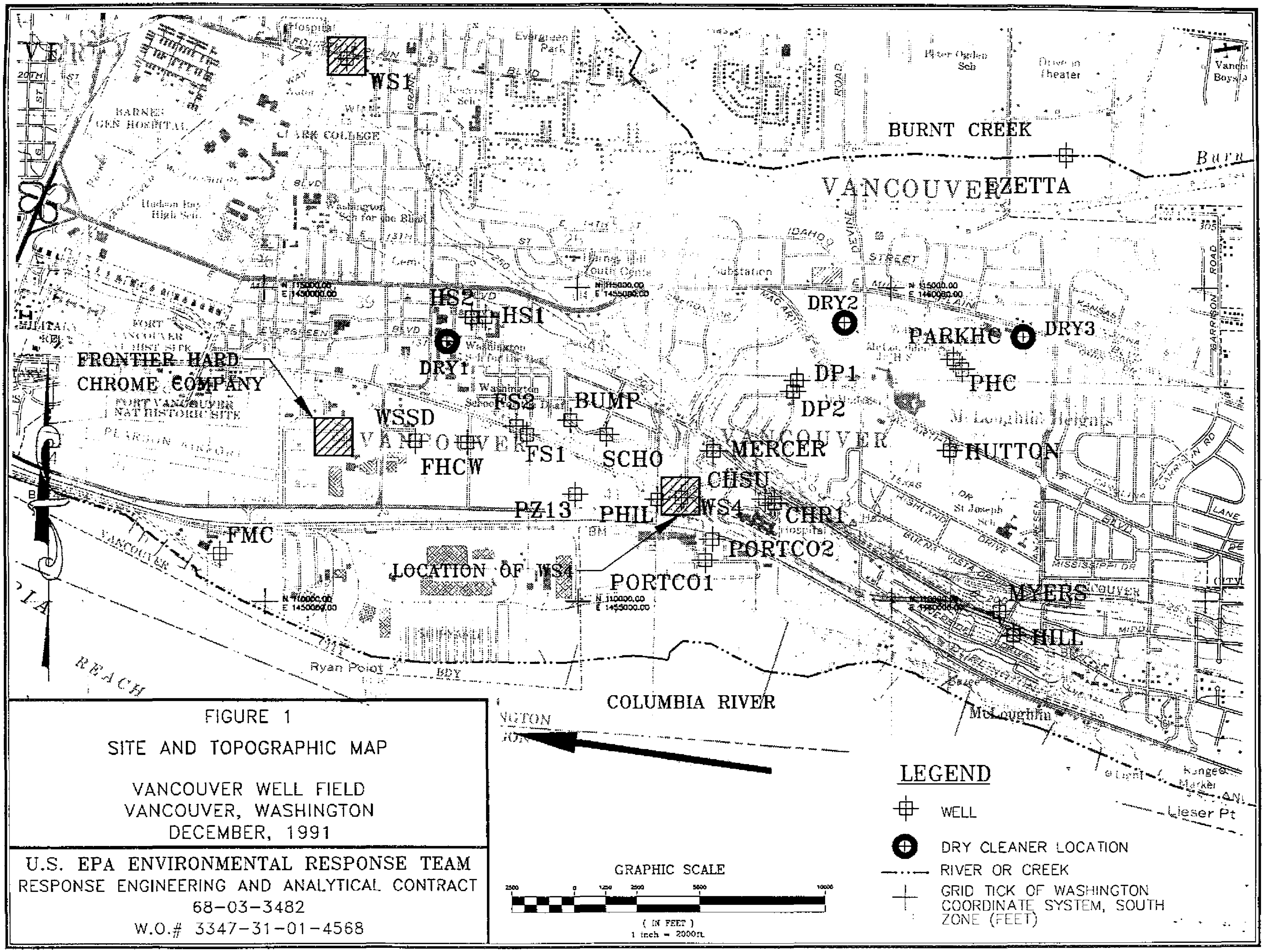

FIGURE 1
SITE AND TOPOGRAPHIC MAP

VANCOUVER WELL FIELD
VANCOUVER, WASHINGTON
DECEMBER, 1991

U.S. EPA ENVIRONMENTAL RESPONSE TEAM
RESPONSE ENGINEERING AND ANALYTICAL CONTRACT
68-03-3482
W.O.# 3347-31-01-4568

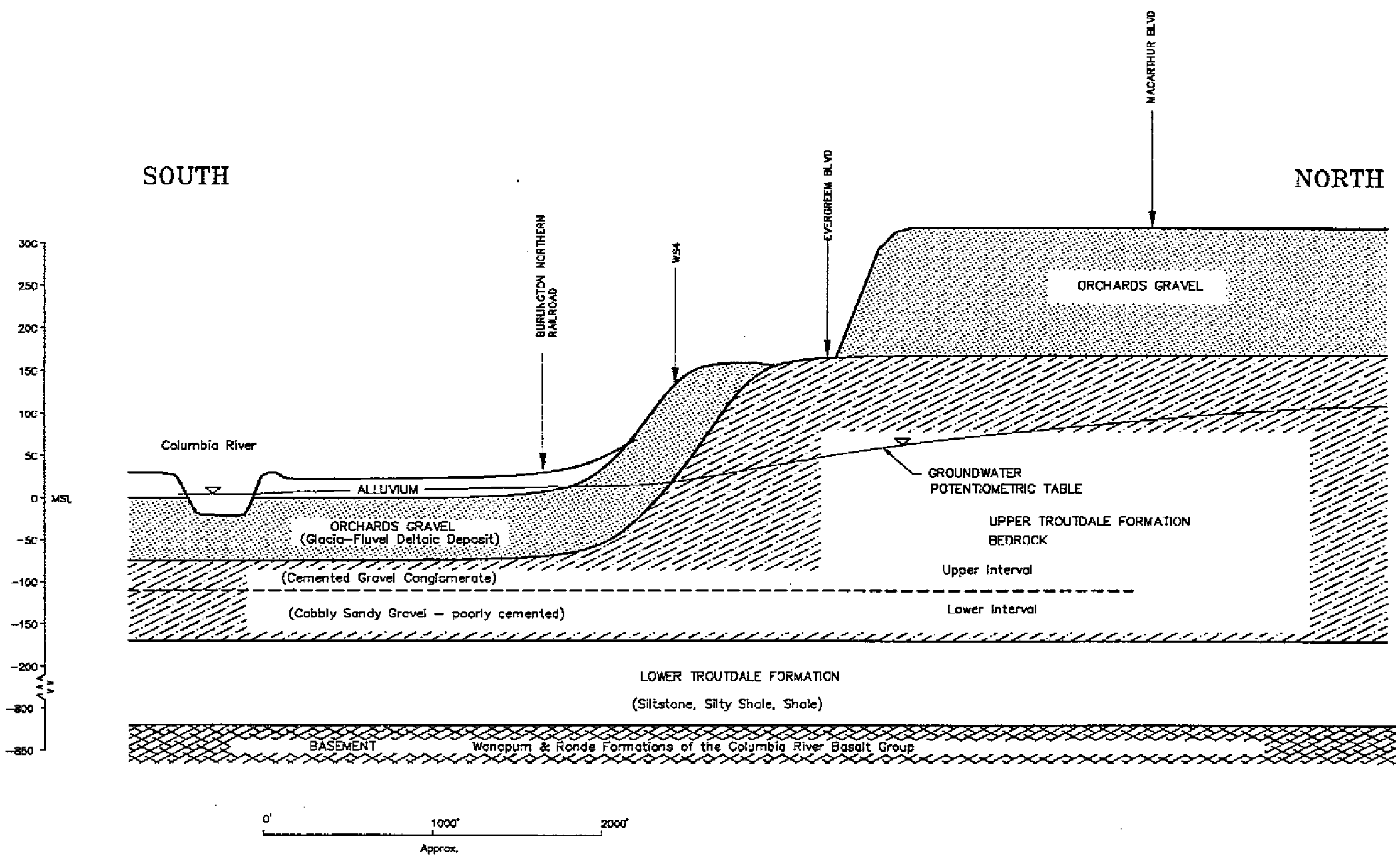

FIGURE 2

GENERALIZED GEOLOGICAL PROFILE

VANCOUVER WELL FIELD
VANCOUVER, WASHINGTON
DECEMBER, 1991

U.S. EPA ENVIRONMENTAL RESPONSE TEAM
RESPONSE ENGINEERING AND ANALYTICAL CONTRACT
68-03-3482
W.O.# 3347-31-01-4568

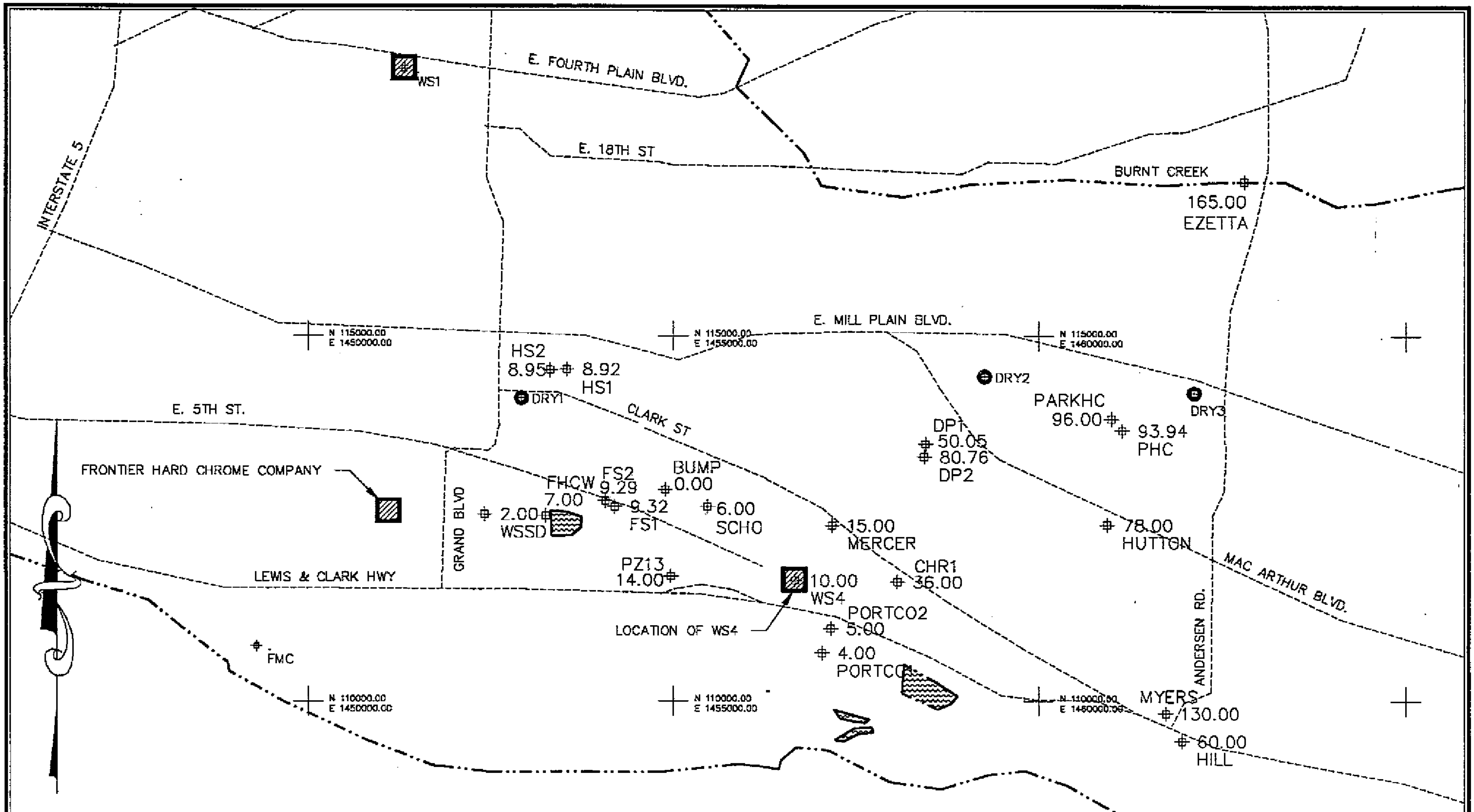

FIGURE 3

GROUNDWATER POTENTIOMETRIC ELEVATIONS

VANCOUVER WELL FIELD
VANCOUVER, WASHINGTON
DECEMBER, 1991

U.S. EPA ENVIRONMENTAL RESPONSE TEAM
RESPONSE ENGINEERING AND ANALYTICAL CONTRACT
68-03-3482
W.O.# 3347-31-01-4568

NOTE:
GROUNDWATER LEVEL DATA FROM RZA REPORT.
DATE OF DATA COLLECTED IS UNKNOWN.

GRAPHIC SCALE

1000 0 500 1000 2000 4000

(IN FEET)
1 inch = 2000ft.

LEGEND

XXX.XX WELL NAME — GROUNDWATER ELEVATION (ft AMSL)

DRY CLEANER LOCATION

ROAD, STREET, OR HIGHWAY

RIVER, CREEK, OR POND

GRID TICK OF WASHINGTON COORDINATE SYSTEM, SOUTH ZONE (FEET)

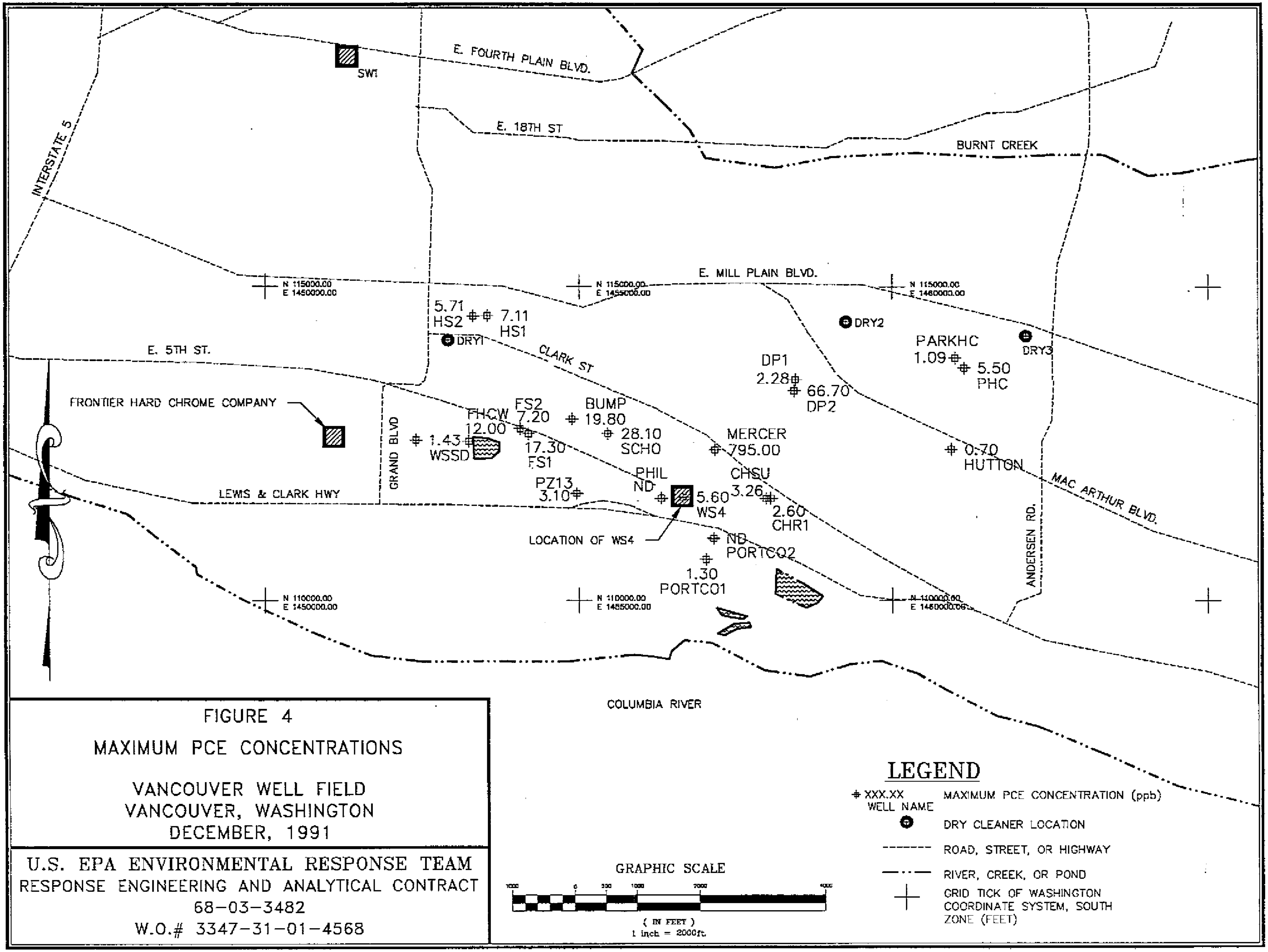

FIGURE 4

MAXIMUM PCE CONCENTRATIONS

VANCOUVER WELL FIELD
VANCOUVER, WASHINGTON
DECEMBER, 1991

U.S. EPA ENVIRONMENTAL RESPONSE TEAM
RESPONSE ENGINEERING AND ANALYTICAL CONTRACT
68-03-3482
W.O.# 3347-31-01-4568

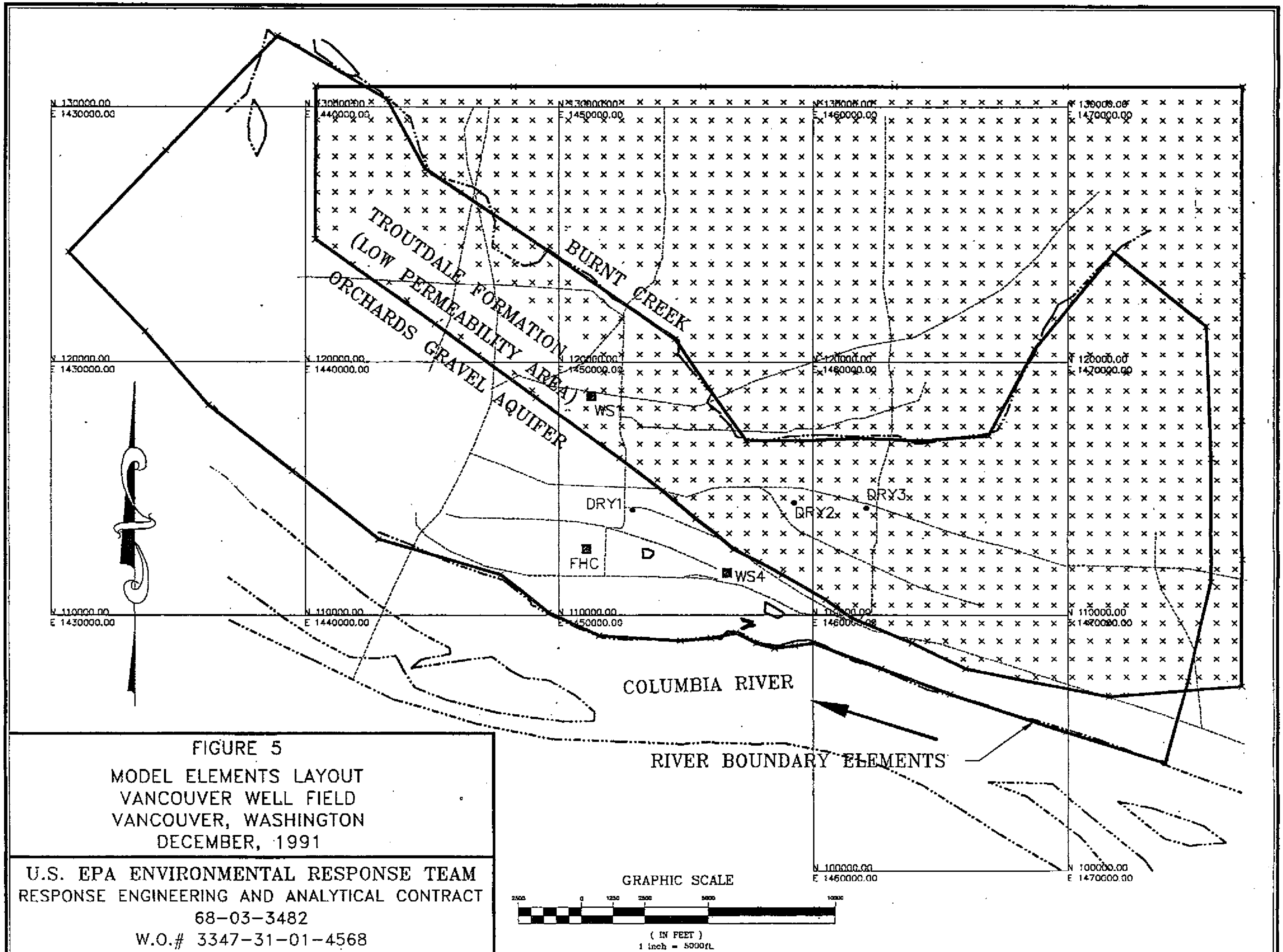

FIGURE 5
MODEL ELEMENTS LAYOUT
VANCOUVER WELL FIELD
VANCOUVER, WASHINGTON
DECEMBER, 1991

U.S. EPA ENVIRONMENTAL RESPONSE TEAM
RESPONSE ENGINEERING AND ANALYTICAL CONTRACT
68-03-3482
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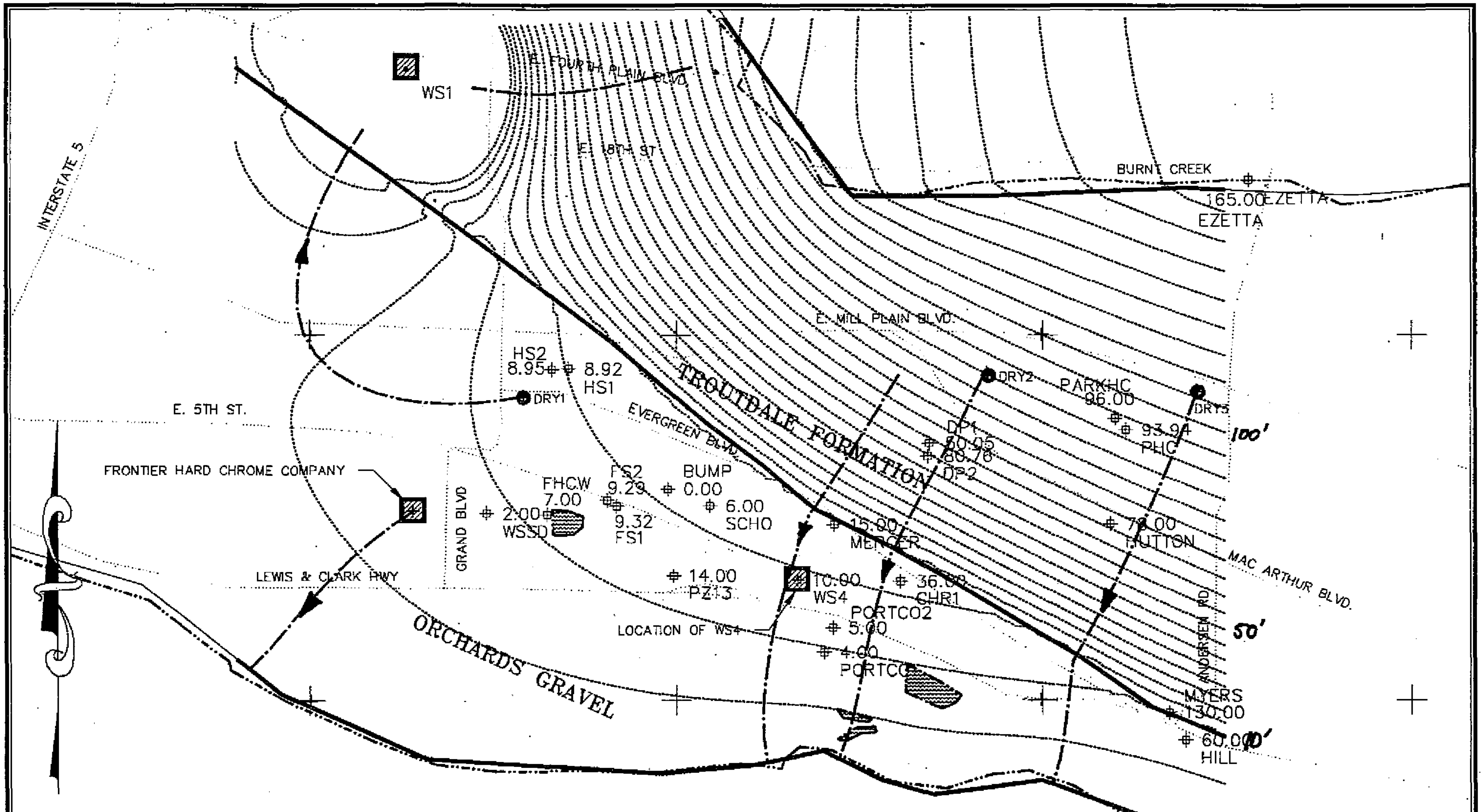

FIGURE 6
MODELED GROUNDWATER CONTOURS
CURRENT CONDITION (WS1 PUMPING)
VANCOUVER WELL FIELD
VANCOUVER, WASHINGTON
DECEMBER, 1991

U.S. EPA ENVIRONMENTAL RESPONSE TEAM
RESPONSE ENGINEERING AND ANALYTICAL CONTRACT
68-03-3482
W.O.# 3347-31-01-4568

NOTE: RELATIVE CONTOUR ELEVATIONS POSTED; ABSOLUTE CONTOUR ELEVATIONS WILL BE DETERMINED WHEN MODELING IS CALIBRATED.

GRAPHIC SCALE

1000 0 500 1000 2000 4000

(IN FEET)
1 inch = 2000ft.

LEGEND

- WELL
- DRY CLEANER LOCATION
- ROAD, STREET, OR HIGHWAY
- RIVER, CREEK, OR POND
- MODELED GROUNDWATER CONTOURS, 5 FEET INT.
- MODELED GROUNDWATER FLOW PATHLINE

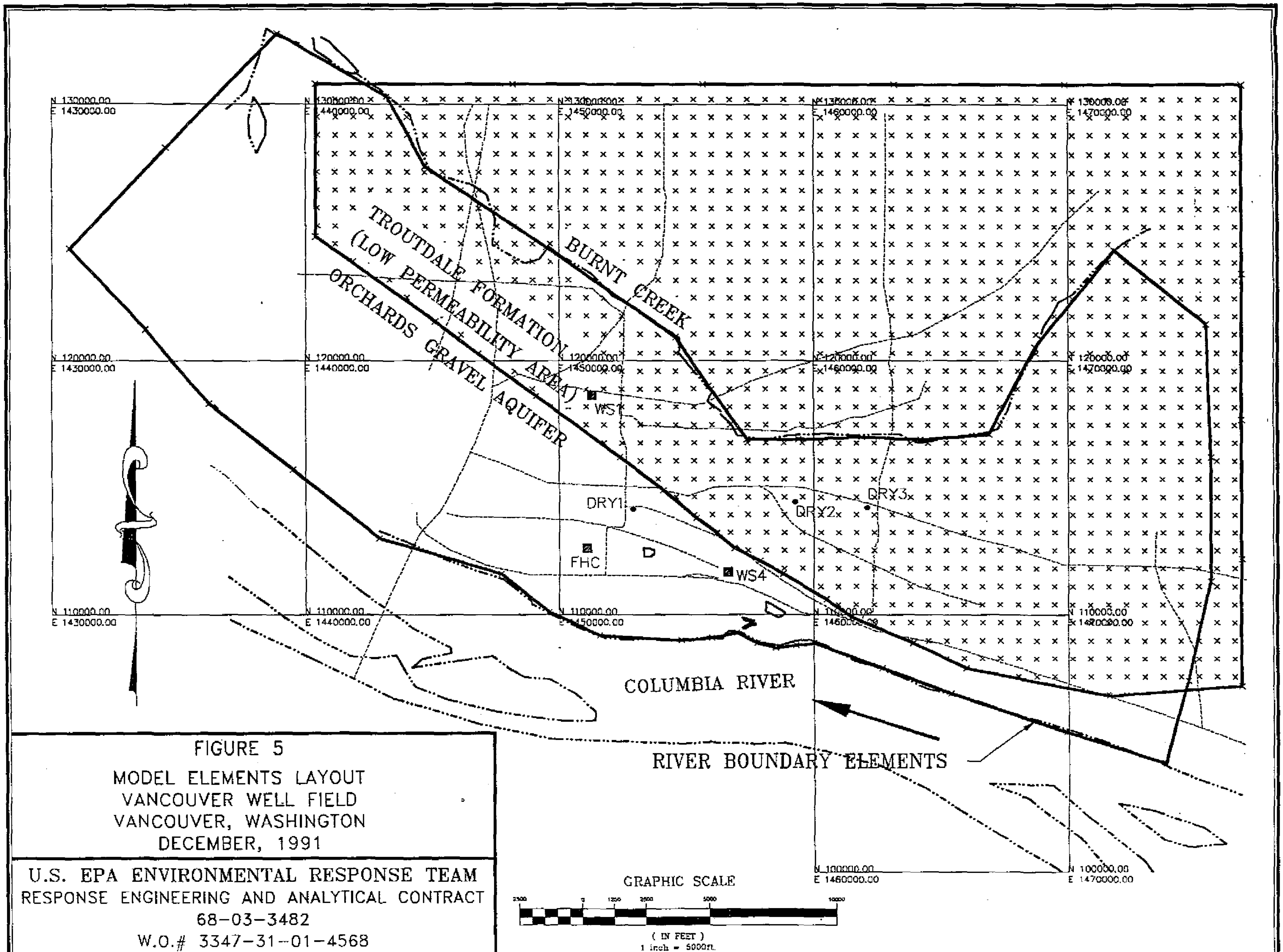

FIGURE 5
MODEL ELEMENTS LAYOUT
VANCOUVER WELL FIELD
VANCOUVER, WASHINGTON
DECEMBER, 1991

U.S. EPA ENVIRONMENTAL RESPONSE TEAM
RESPONSE ENGINEERING AND ANALYTICAL CONTRACT
68-03-3482
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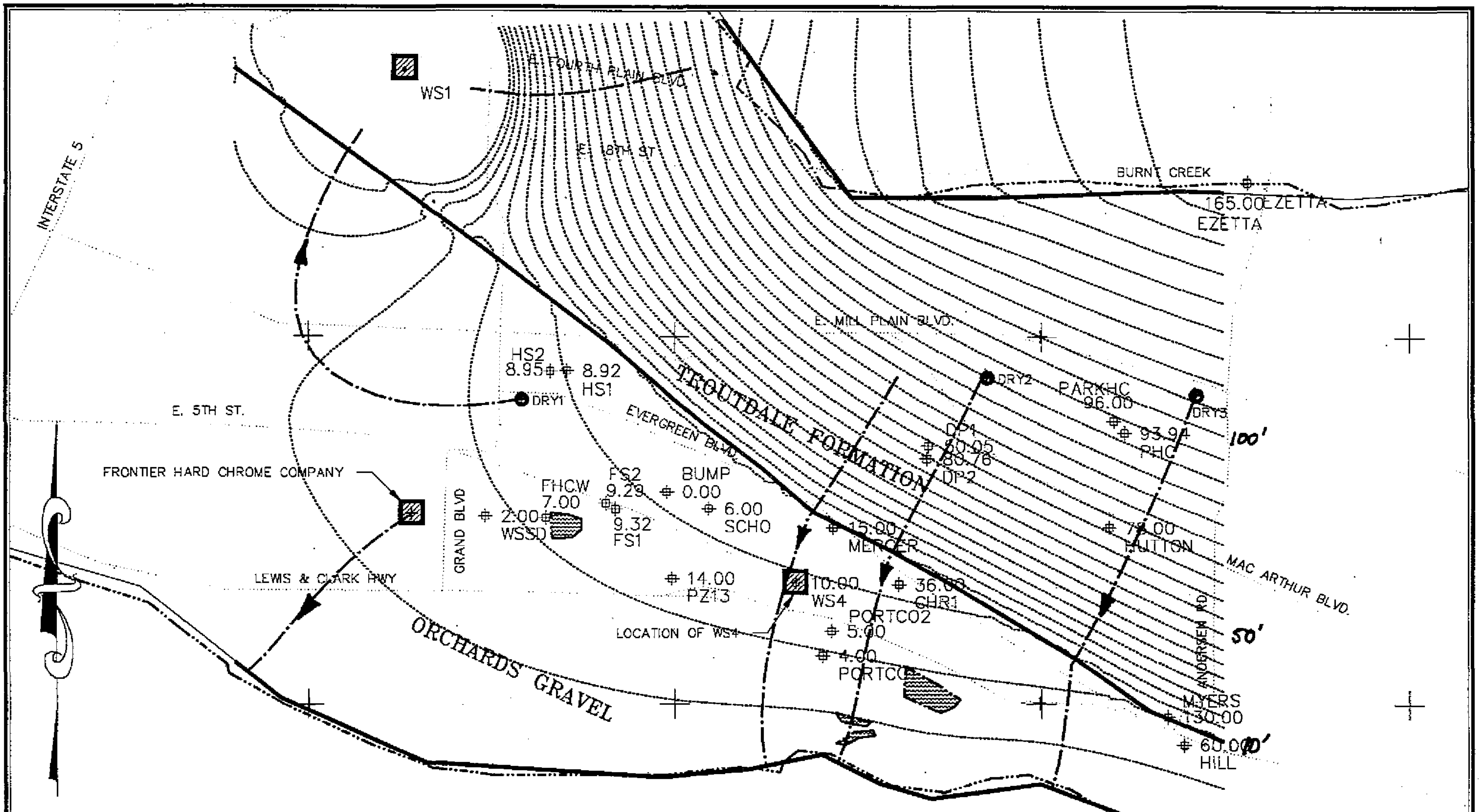

FIGURE 6
MODELED GROUNDWATER CONTOURS
CURRENT CONDITION (WS1 PUMPING)
VANCOUVER WELL FIELD
VANCOUVER, WASHINGTON
DECEMBER, 1991

U.S. EPA ENVIRONMENTAL RESPONSE TEAM
RESPONSE ENGINEERING AND ANALYTICAL CONTRACT
68-03-3482
W.O.# 3347-31-01-4568

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GRAPHIC SCALE

1000 0 500 1000 2000 4000

(IN FEET)
1 inch = 2000ft.

LEGEND

- WELL
- DRY CLEANER LOCATION
- ROAD, STREET, OR HIGHWAY
- RIVER, CREEK, OR POND
- MODELED GROUNDWATER CONTOURS, 5 FEET INT.
- MODELED GROUNDWATER FLOW PATHLINE

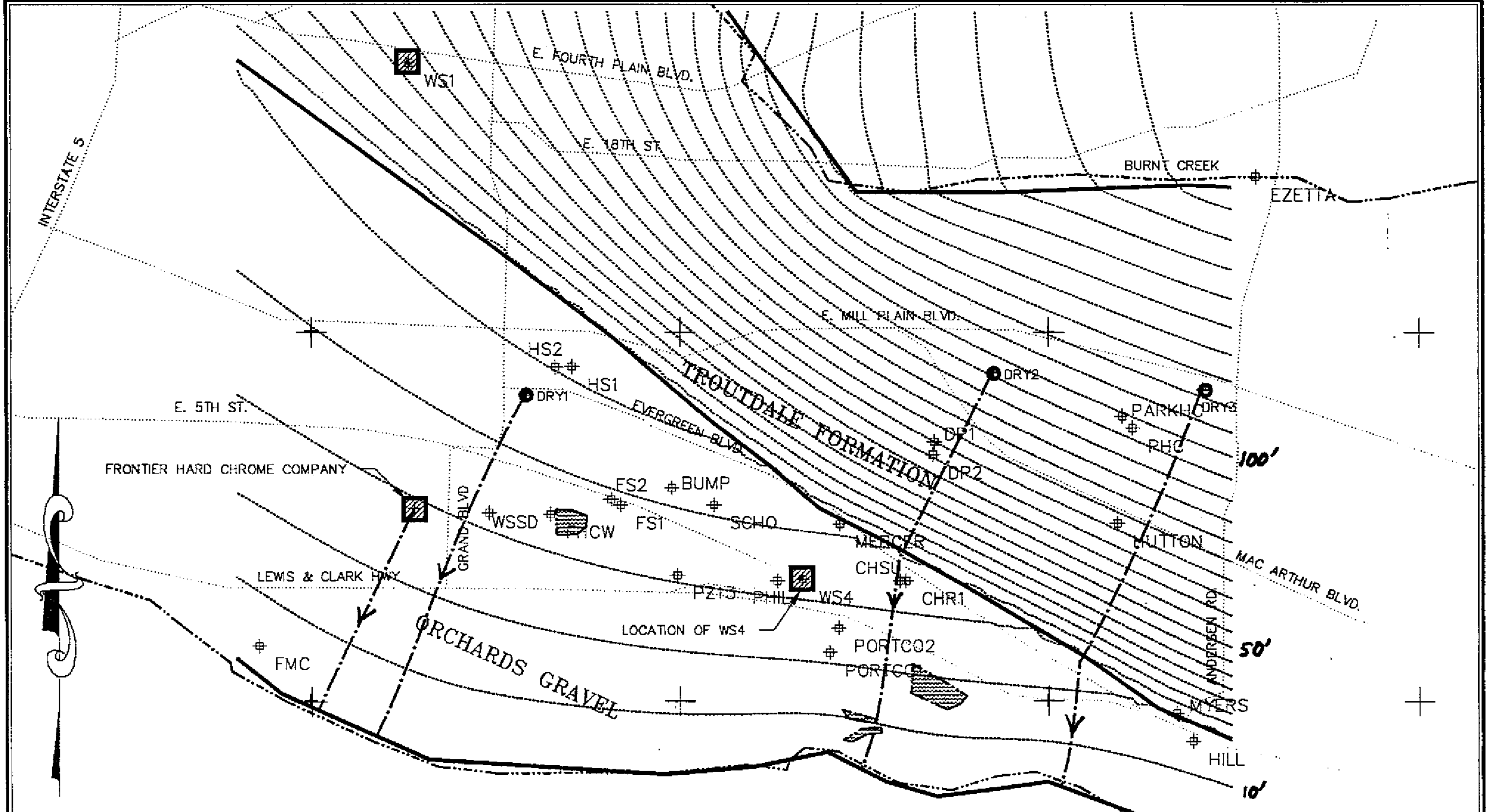


FIGURE 7
MODELED GROUNDWATER CONTOURS
STATIC CONDITION
VANCOUVER WELL FIELD
VANCOUVER, WASHINGTON
DECEMBER, 1991

U.S. EPA ENVIRONMENTAL RESPONSE TEAM
RESPONSE ENGINEERING AND ANALYTICAL CONTRACT
68-03-3482
W.O.# 3347-31-01-4568

NOTE: RELATIVE CONTOUR ELEVATIONS POSTED; ABSOLUTE CONTOUR ELEVATIONS WILL BE DETERMINED WHEN MODELING IS CALIBRATED.

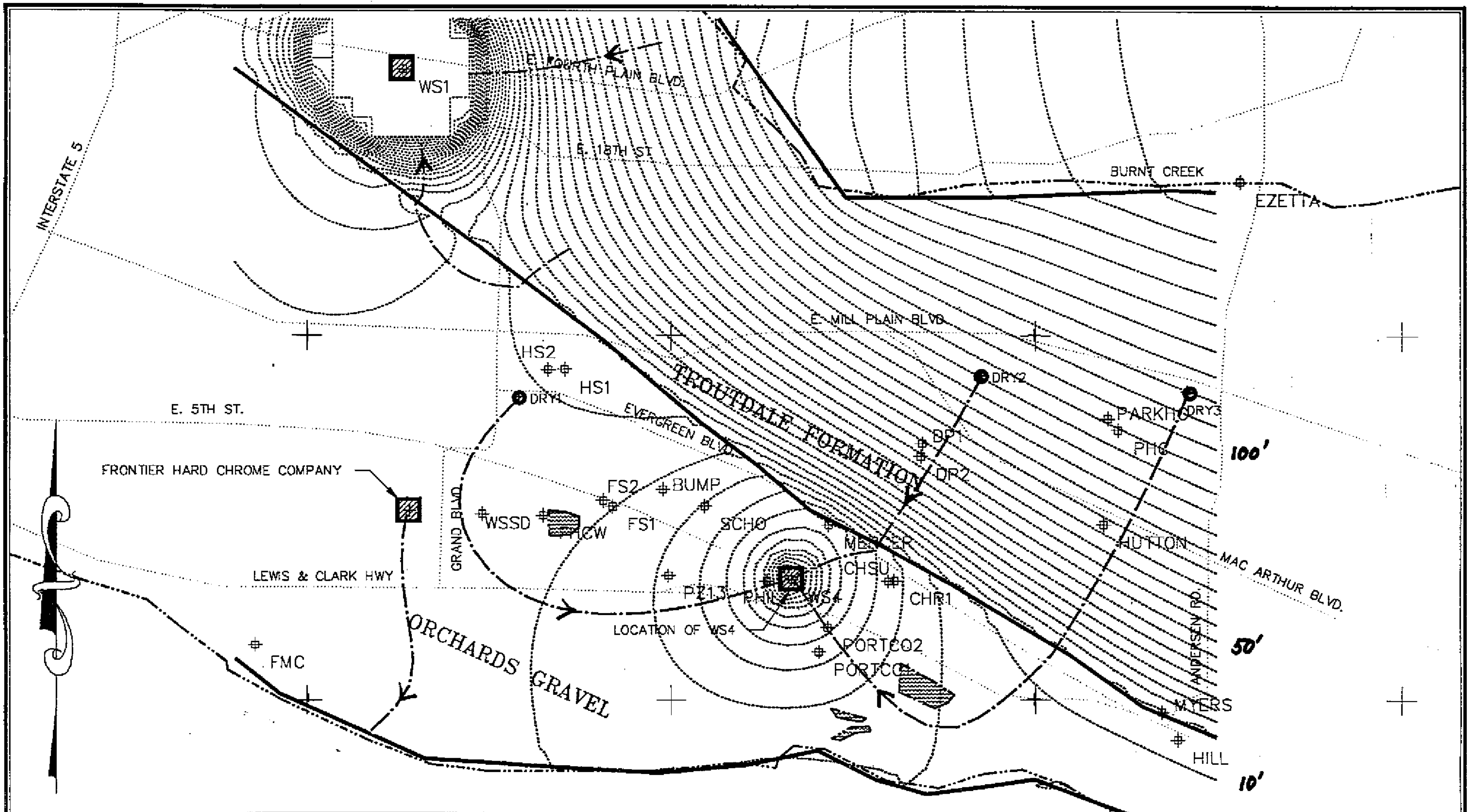
GRAPHIC SCALE

1000 0 500 1000 2000 4000

(IN FEET)
1 inch = 2000ft.

LEGEND

- WELL
- DRY CLEANER LOCATION
- ROAD, STREET, OR HIGHWAY
- RIVER, CREEK, OR POND
- MODELED GROUNDWATER CONTOURS, 5 FEET INT.
- MODELED GROUNDWATER FLOW PATHLINE



COLUMBIA RIVER

FIGURE 8
MODELED GROUNDWATER CONTOURS
WS4 PUMPING 4000 GPM
VANCOUVER WELL FIELD
VANCOUVER, WASHINGTON
DECEMBER, 1991

U.S. EPA ENVIRONMENTAL RESPONSE TEAM
RESPONSE ENGINEERING AND ANALYTICAL CONTRACT
68-03-3482
W.O.# 3347-31-01-4568

NOTE: RELATIVE CONTOUR ELEVATIONS POSTED; ABSOLUTE CONTOUR ELEVATIONS WILL BE DETERMINED WHEN MODELING IS CALIBRATED.

GRAPHIC SCALE

1000 0 500 1000 2000 4000

(IN FEET)
1 inch = 2000ft.

LEGEND

- WELL
- DRY CLEANER LOCATION
- ROAD, STREET, OR HIGHWAY
- RIVER, CREEK, OR POND
- MODELED GROUNDWATER CONTOURS, 5 FEET INT.
- MODELED GROUNDWATER FLOW PATHLINE

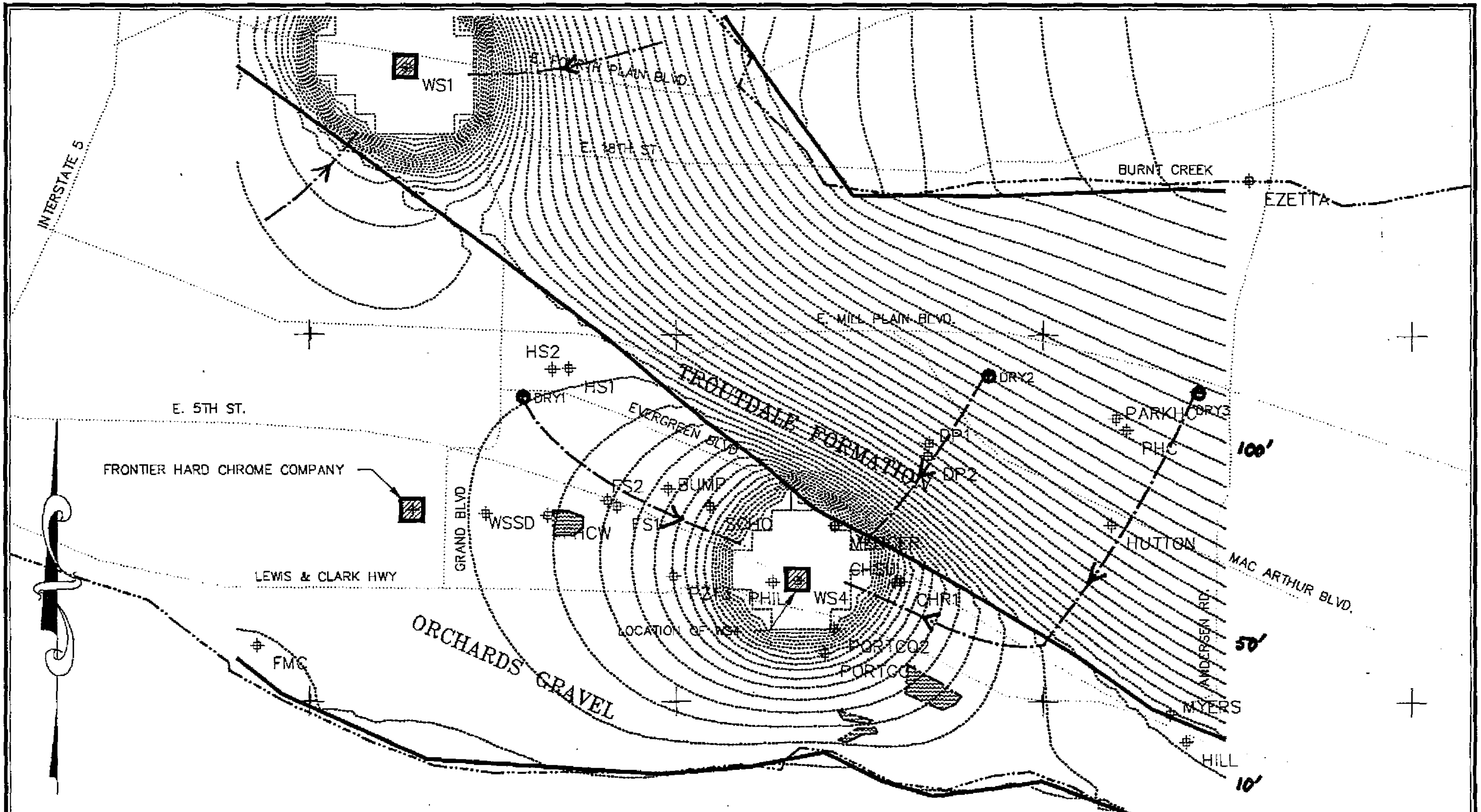


FIGURE 9
MODELED GROUNDWATER CONTOURS
WS4 PUMPING 8000 GPM
VANCOUVER WELL FIELD
VANCOUVER, WASHINGTON
DECEMBER, 1991

U.S. EPA ENVIRONMENTAL RESPONSE TEAM
RESPONSE ENGINEERING AND ANALYTICAL CONTRACT
68-03-3482
W.O.# 3347-31-01-4568

NOTE: RELATIVE CONTOUR ELEVATIONS POSTED; ABSOLUTE CONTOUR ELEVATIONS WILL BE DETERMINED WHEN MODELING IS CALIBRATED.

GRAPHIC SCALE

(IN FEET)
1 inch = 2000 ft.

LEGEND

- WELL
- DRY CLEANER LOCATION
- ROAD, STREET, OR HIGHWAY
- RIVER, CREEK, OR POND
- MODELED GROUNDWATER CONTOURS, 5 FEET INT.
- MODELED GROUNDWATER FLOW PATHLINE

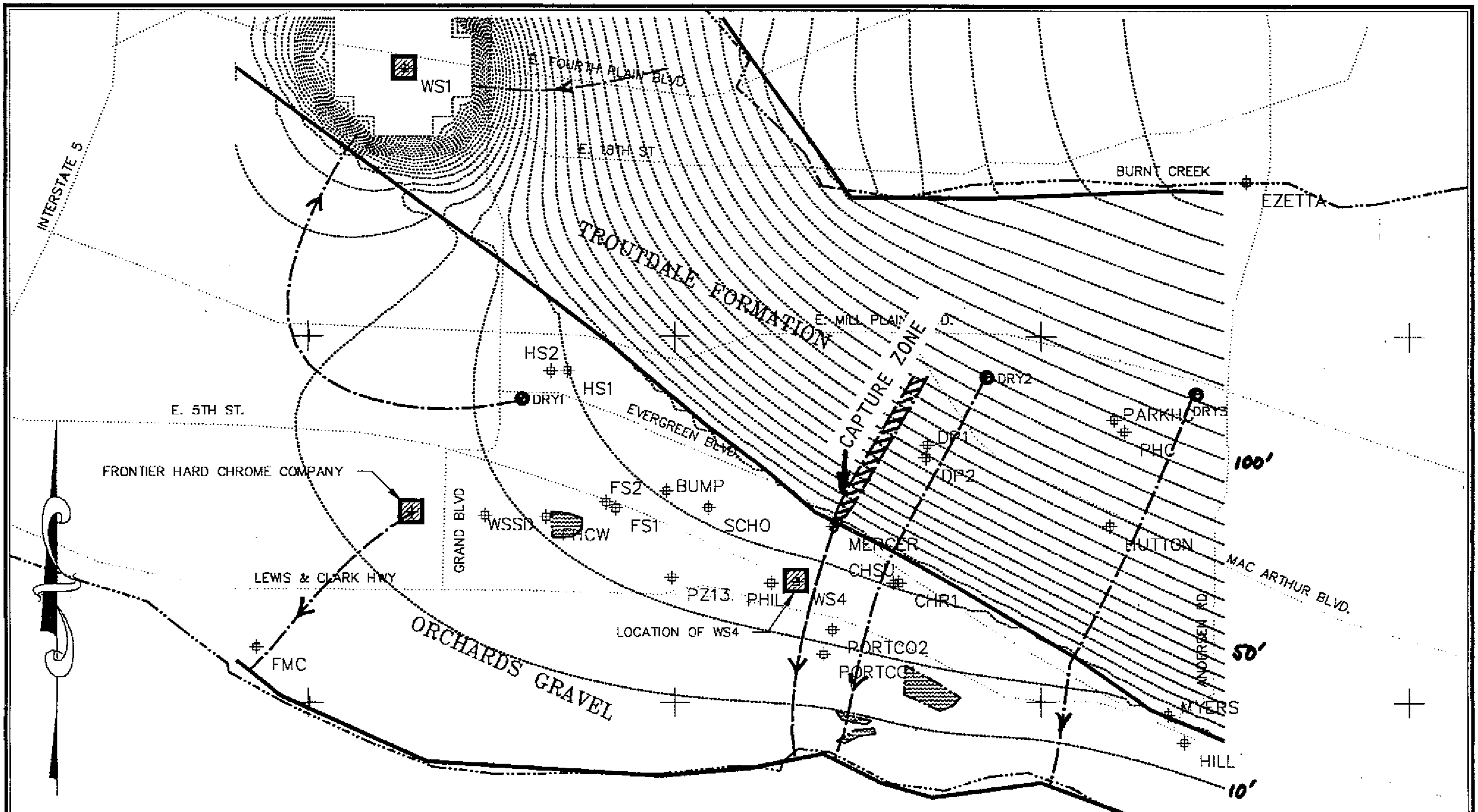


FIGURE 10
MODELED GROUNDWATER CONTOURS
MERCER WELL PUMPING 100 GPM
VANCOUVER WELL FIELD
VANCOUVER, WASHINGTON
DECEMBER, 1991

U.S. EPA ENVIRONMENTAL RESPONSE TEAM
RESPONSE ENGINEERING AND ANALYTICAL CONTRACT
68-03-3482
W.O.# 3347-31-01-4568

NOTE: RELATIVE CONTOUR ELEVATIONS POSTED: ABSOLUTE CONTOUR ELEVATIONS WILL BE DETERMINED WHEN MODELING IS CALIBRATED.

GRAPHIC SCALE

1000 0 500 1000 2000 4000

(IN FEET)
1 inch = 2000ft.

LEGEND

- WELL
- DRY CLEANER LOCATION
- ROAD, STREET, OR HIGHWAY
- RIVER, CREEK, OR POND
- MODELED GROUNDWATER CONTOURS, 5 FEET INT.
- MODELED GROUNDWATER FLOW PATHLINE